RETROFITTING PLANTS FOR CARBON CAPTURE AND UTILIZATION: REDEFINING THE CARBON SUPPLY CHAIN

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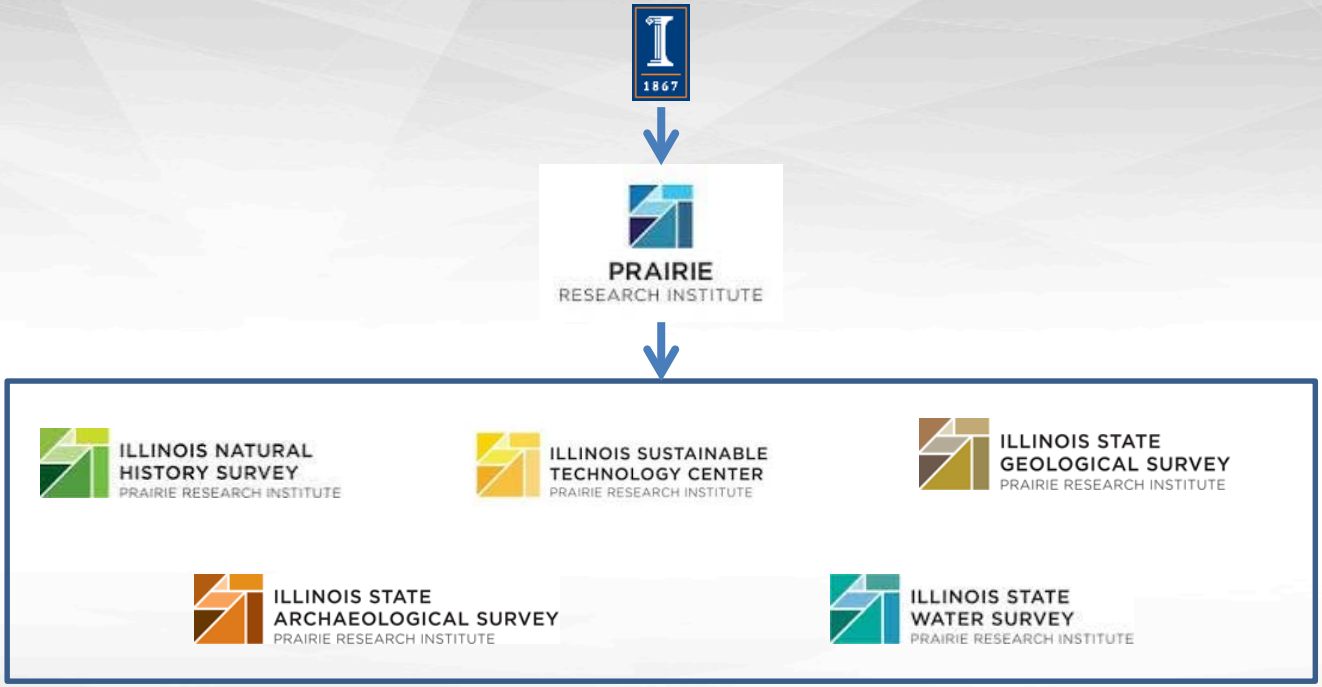
Prairie Research Institute: Illinois-focused Resource Research and Service

Addressing societal challenges that impact Illinois and the global community



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Overview

Examining from a state-wide perspective

- Status of large scale CO_2 capture pilot
  - Phase 2 proposal submitted to DOE for 15 MW large scale capture pilot
- Select utilization options synergistic with regional economy
  - Preferred options can vary throughout one state or region
- Identify relevant workforce development partners
  - Related to utilization options and part of CO_2 value chain
- Develop tools to connect CO_2 utilization with existing economy
  - Tools to examine dispatching of CO_2

Phase 2 proposal (Design, Build, Operate) submitted

STATUS OF LARGE SCALE PILOT

Host Site: Abbott Power Plant

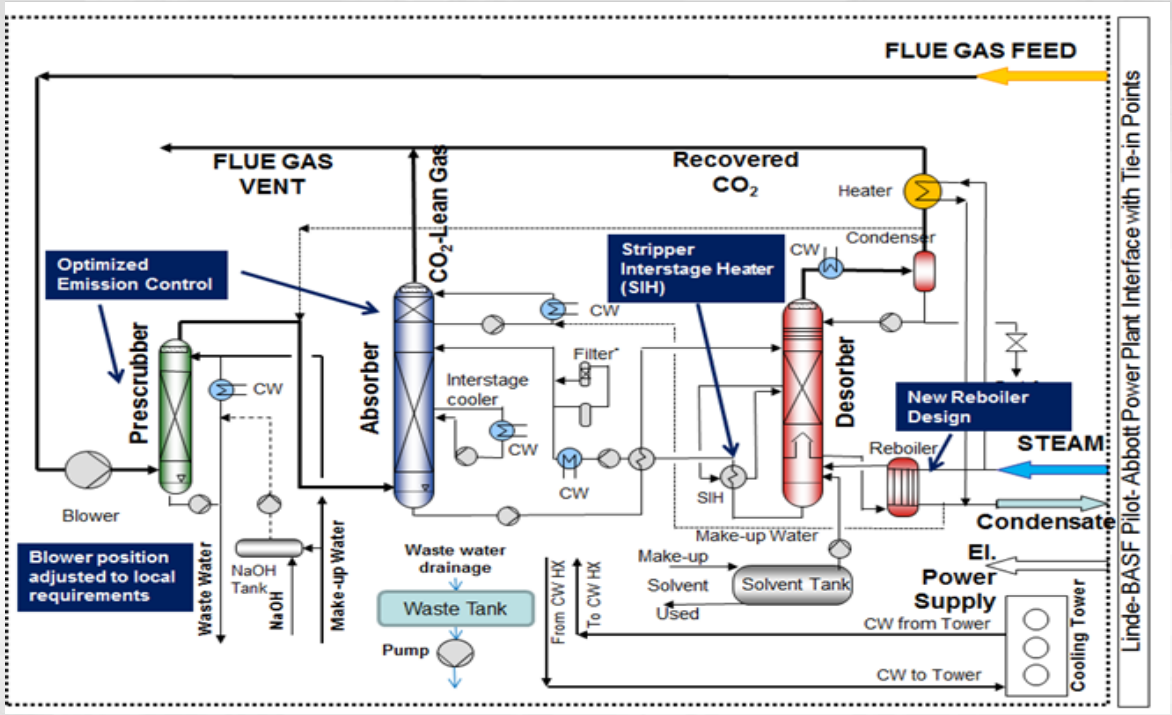
Ideal site for large scale pilot testing of coal and natural gas

- Seven boilers total: three are coal based (Chain-grate stoker design) others natural gas
- **Coal side has completely separate treatment system from natural gas side**
- For testing will run two coal boilers
- Illinois high sulfur coal is burned
- Electrostatic precipitators and a wet Flue Gas Desulfurizer (FGD) in place
- **Tradition of evaluating new emission technologies**
- **Tradition of showcasing technologies to other power plants and education groups**

Major advantage that University owns and operates Host Site

Overview of Capture System for Large Pilot Plant

Technology features



Process Performance and Cost Summary 550 MW

Based on 1.5 MWe Testing

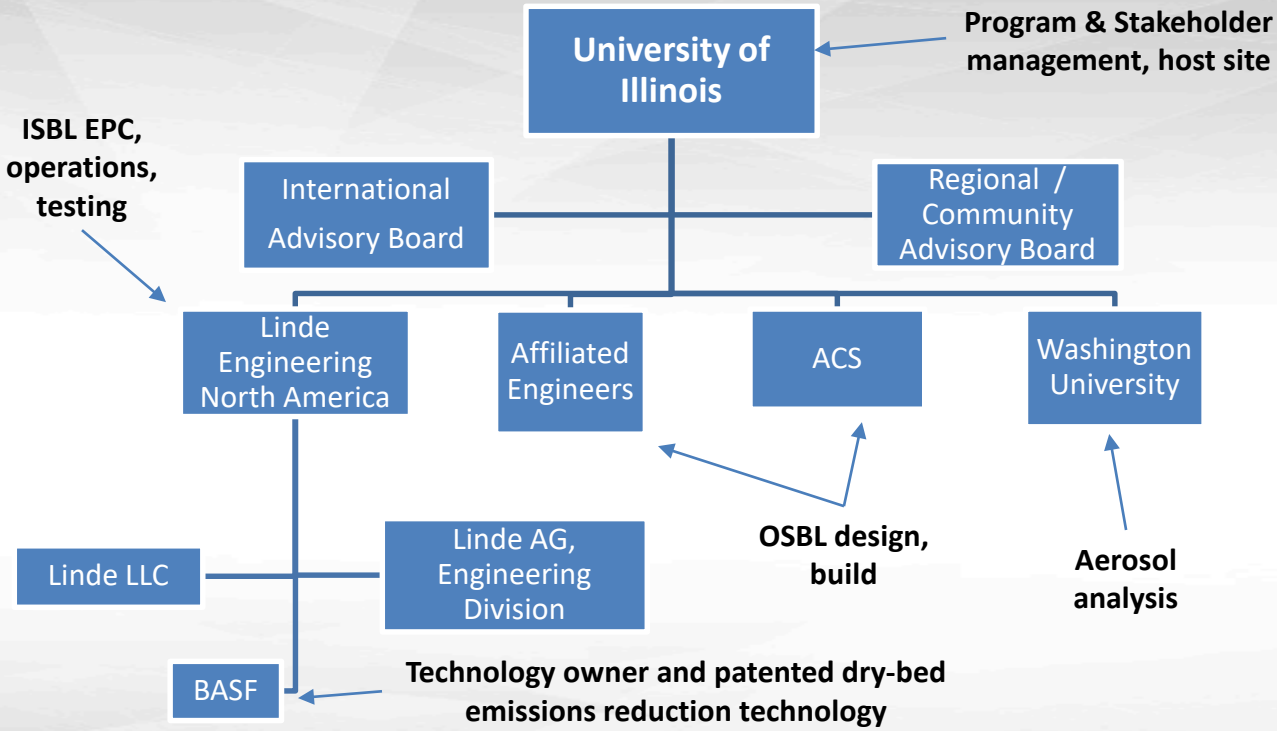
Table 4. Process performance and cost summary for DOE/NETL cases compared to Linde-BASF technologies

Parameter	NETL Case 11	NETL Case 12	Linde Case LB1	Linde Case SIH
Scenario	No capture	CO_2 Capture with MEA	CO_2 Capture with OASE® blue	CO_2 Capture with OASE® blue and SIH
Net power output (MWe)	550	550	550	550
Gross power output (MWe)	580.3	662.8	638.9	637.6
Coal flow rate (tonne/hr)	186	257	236	232
Net HHV plant efficiency (%)	39.3%	28.4%	30.9%	31.4%
Total overnight cost ($2011)	1,348	2,415	1,994	1,959
Cost of captured CO_2 with TS&M ($/MT)	N/A	67	52	50
Cost of captured CO_2 without TS&M ($/MT)	N/A	57	42	40
COE (mills/kWh) with TS&M cost included	81.0	147.3	128.5	126.5

LB1 - Linde-BASF PCC plant incorporating BASF's OASE® blue aqueous amine-based solvent
SIH - New Linde-BASF PCC plant incorporating the same BASF OASE® blue solvent featuring an advanced stripper inter-stage heater design

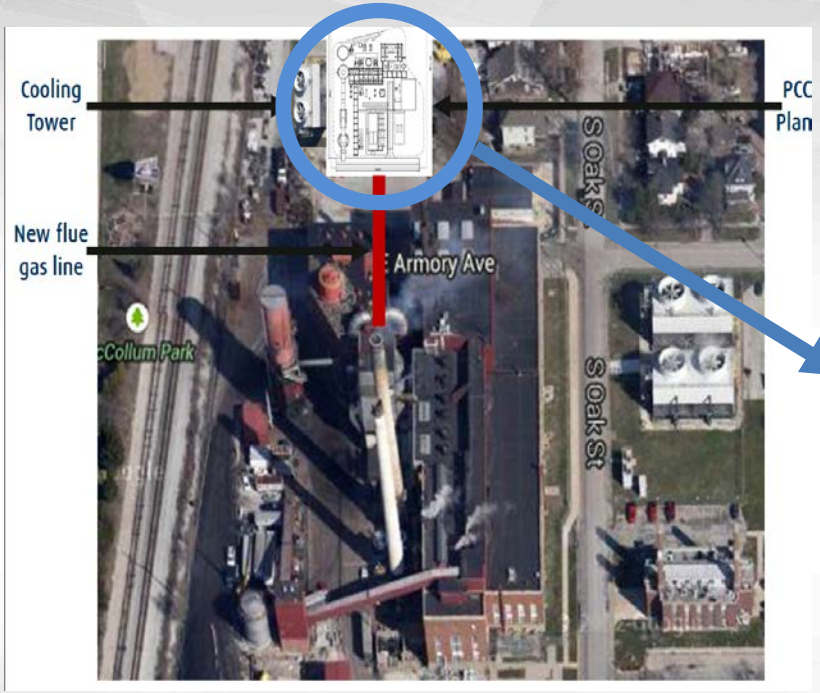
Phase 2: Project Organization Chart

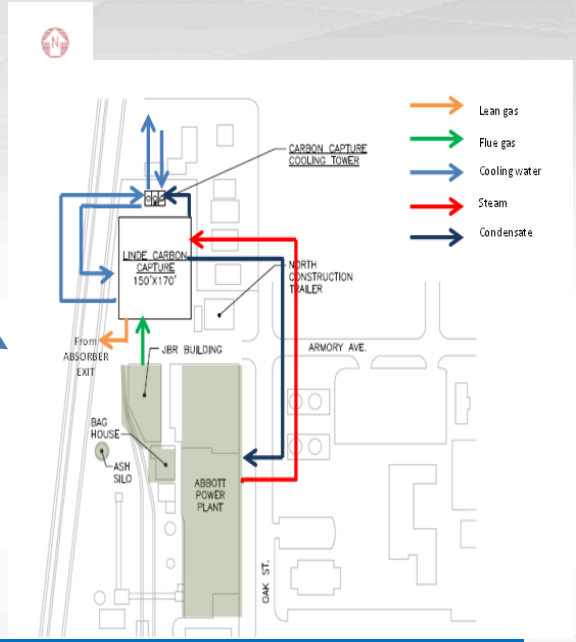
Added expertise in aerosols, OSBL procurement / construction, and dry-bed emissions reduction



Site for Carbon Capture Plant Established and Evaluated

Located close to Abbott Power Plant



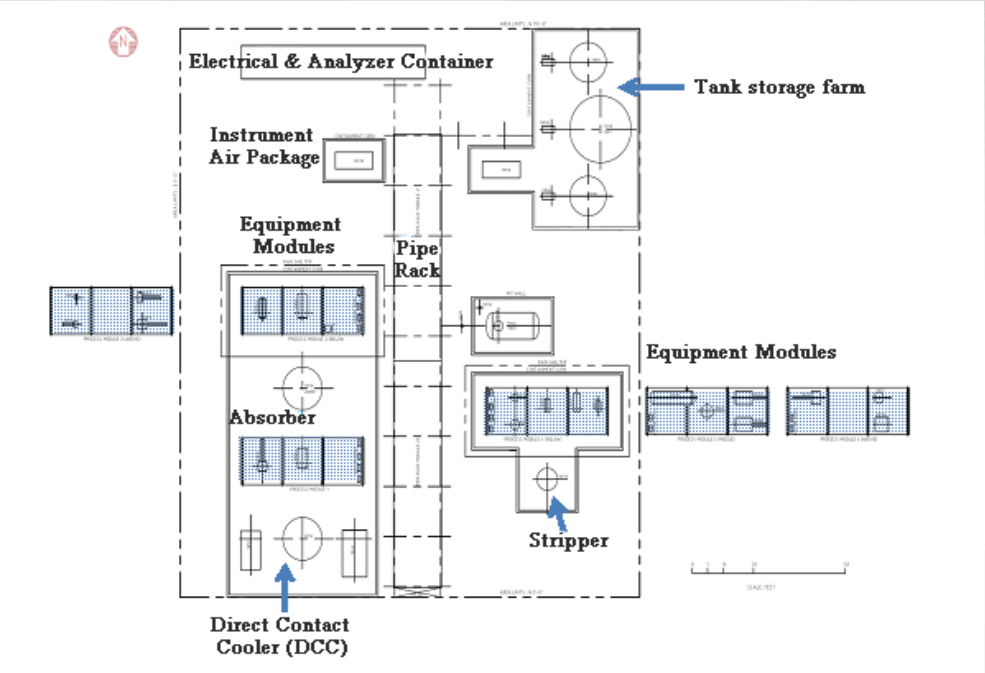


Extract flue gas POST CEMS Unit

Plot Plan for Capture Plant

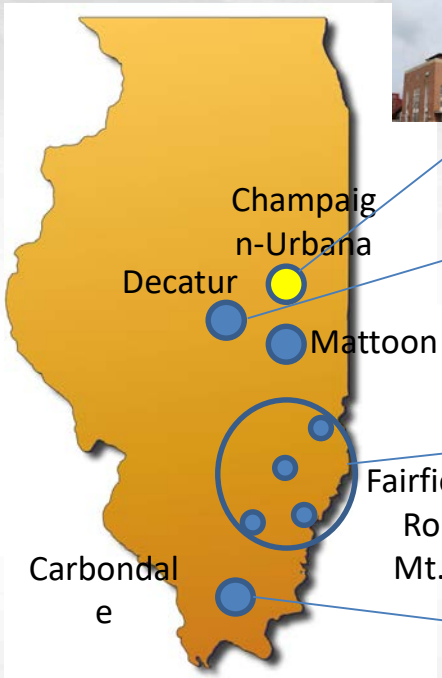
49 m x 46 m (160 ft. x 150 ft.) footprint

No modifications to existing plant combustion system (i.e. boilers) considered a major risk reduction by Abbott Power Plant



Regional & Global Test Bed for CCUS

Concentration of natural resources and intellectual capital



- Capture of CO_2 : Abbott Power Plant
  UIUC

ADM MGSC Richland COMMUNITY COLLEGE

- Storage of CO_2 : ADM Project

MATTOON
MATTOON, ILLINOIS: *Working Together to Build the Future*

- Utilization of CO_2 : Enhanced Oil Recovery (EOR)

Illinois Eastern Community Colleges

- Operator Training

Southern Illinois University Carbondale

- Coal combustion

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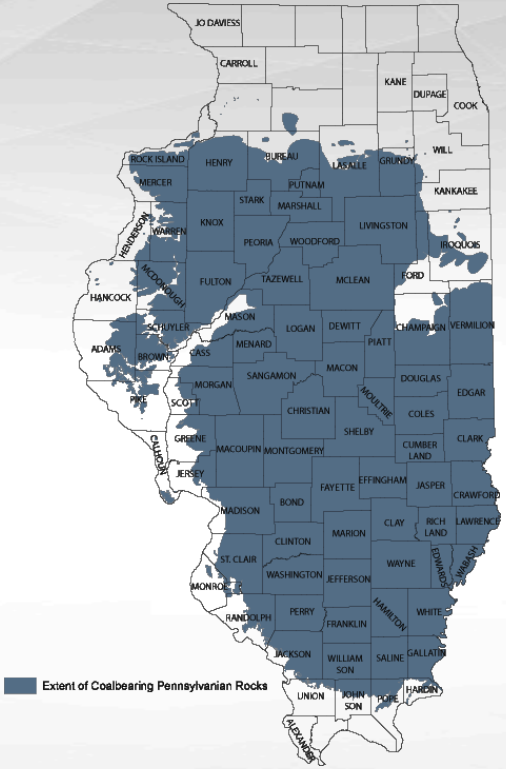
Important to consider regional economy

SYNERGISTIC UTILIZATION OPTIONS

Coal: A Significant Resource for Illinois

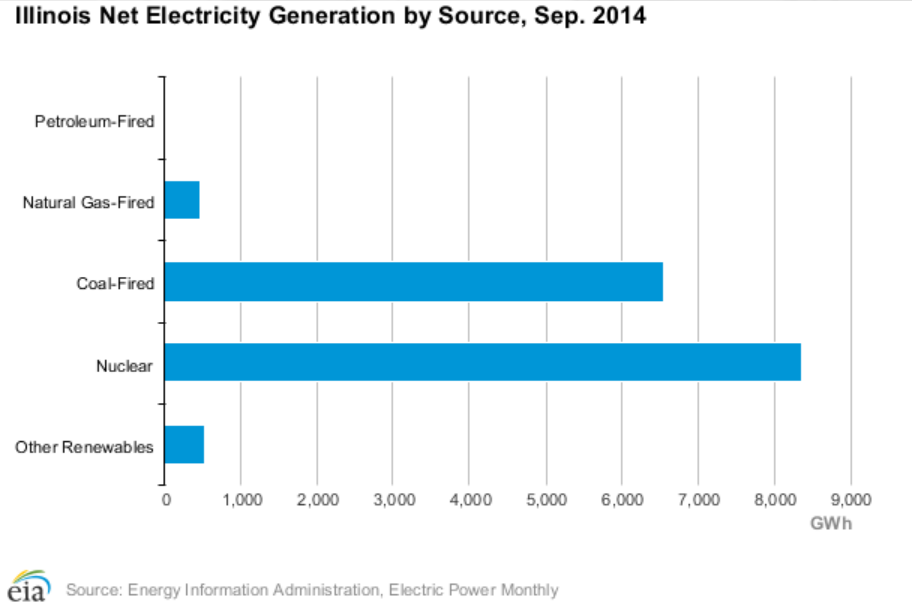
Underlies 95,830 m^2 (37,000 mi^2) or 68% of Illinois

- More than 211 billion tons of identified resources are currently estimated to lie beneath the state
- Demonstrated reserve base is 112 billion tons, as defined in terms of minimum thickness and some geologic assurance of coal's presence
- Demonstrated coal reserve base is the second largest in the United States and, for bituminous coal, is the largest in the nation
- Over $2.5 billion in annual economic activity within the State,
- Employing approximately 5,000 miners with an average annual salary of $85,000
- Higher than both the United States and Illinois median household incomes



Illinois Energy Portfolio

Nuclear and coal are key



Other Relevant Illinois Metrics

Factors considered when evaluating CO_2 Utilization options

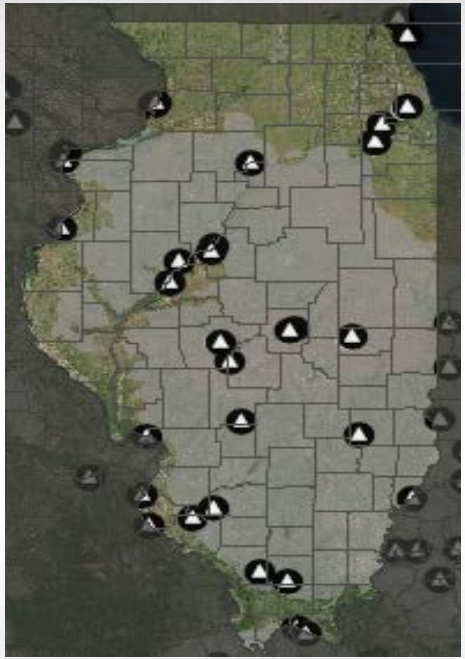
- Leads the Midwest in crude oil refining capacity and ranked fourth in the nation (January 2015)
- Second in the nation in recoverable coal reserves at producing mines (2013)
- Third largest producer of ethanol (production capacity of 1.5 billion gallons per year)

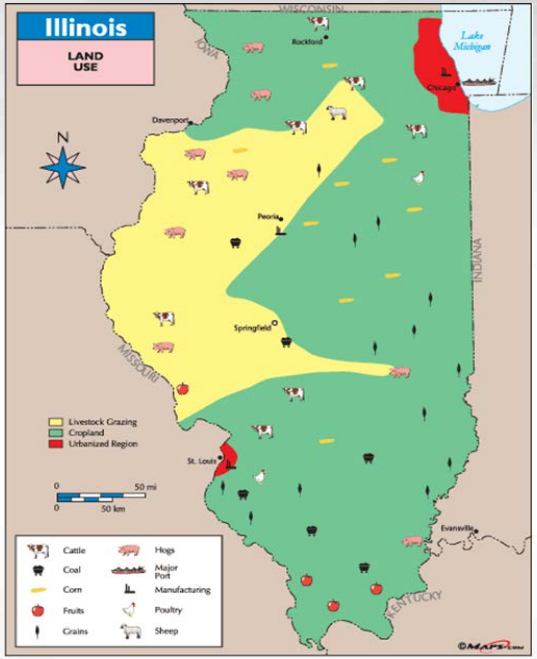
Source: http://www.eia.gov/state/analysis.cfm?sid=IL

Connection Between Coal-Fired Plants and Agriculture

Long standing relationship in Illinois

Coal fired Power Plants





Coal-Fired Power Plants and Refineries / Chemicals

Focus on more urban areas

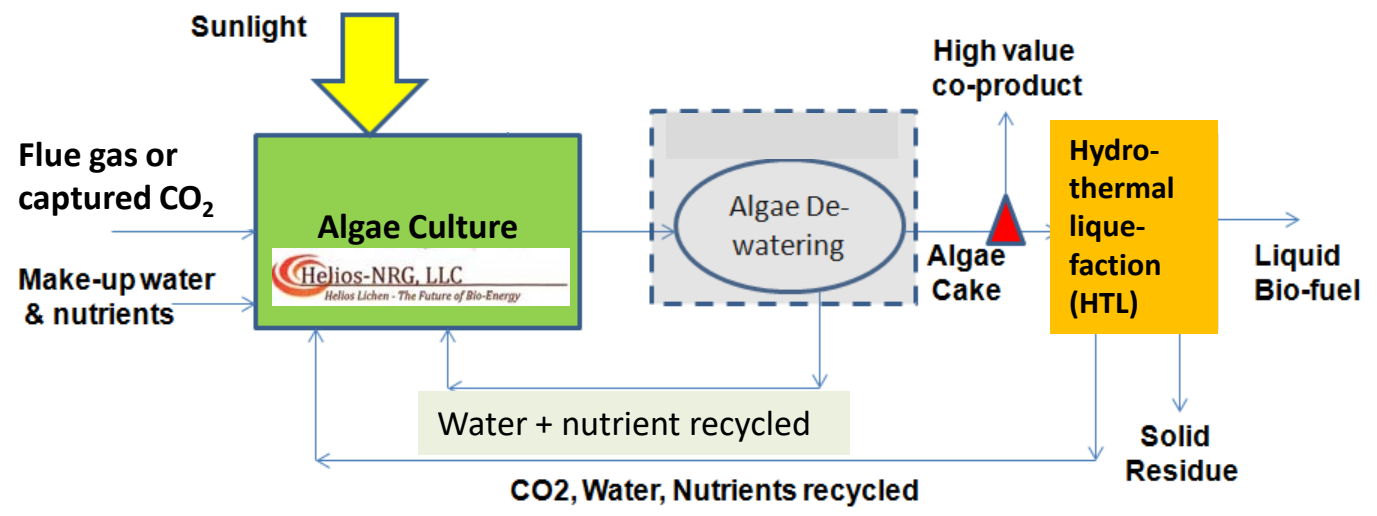
Coal fired Power Plants

Refineries

Source: http://www.eia.gov/state/analysis.cfm?sid=IL

CO_2 Utilization with Algae

Synergistic with agricultural economy in Illinois



Range of HTL Reactors Available at University of Illinois

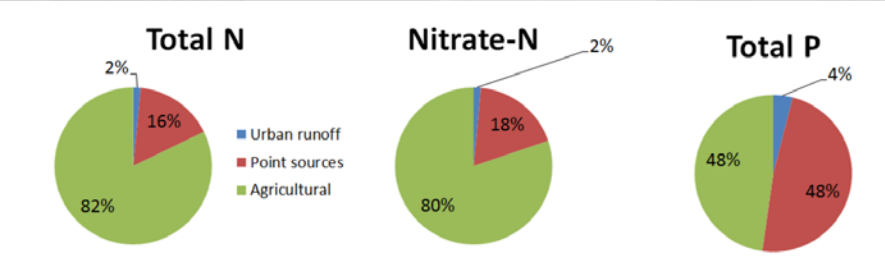
Enables coupling with large scale capture pilot

100 mL Batch HTL reactors

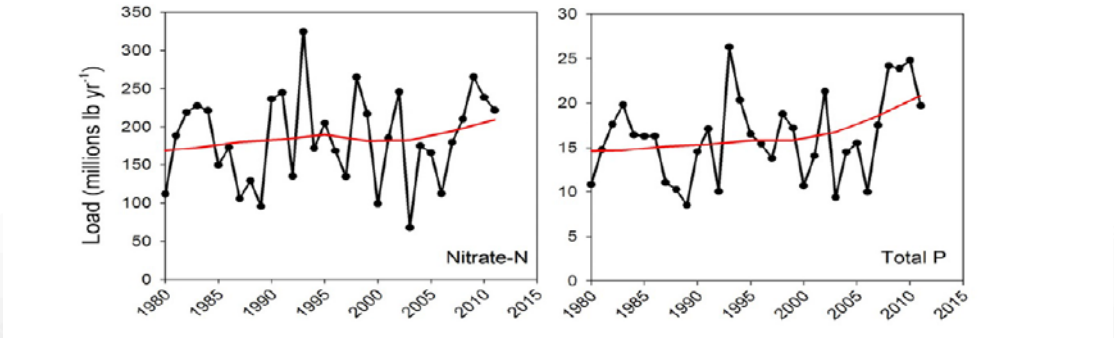
10 ton/day Continuous Flow HTL Pilot System

Nutrient Loss Reduction: Critical to Illinois Agriculture

Plan required to reduce nutrients (N and P) carried in rivers and to the Gulf of Mexico



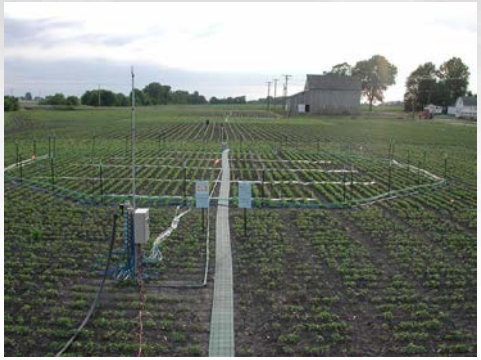
Nutrient sources in Illinois contributing to riverine nutrient export from the state



Annual nitrate-nitrogen and total phosphorus loads from Illinois

SoyFACE: Evaluating Elevated CO_2 Levels on Crop Growth

Free Air Concentration Enrichment (FACE) approach requires no enclosure



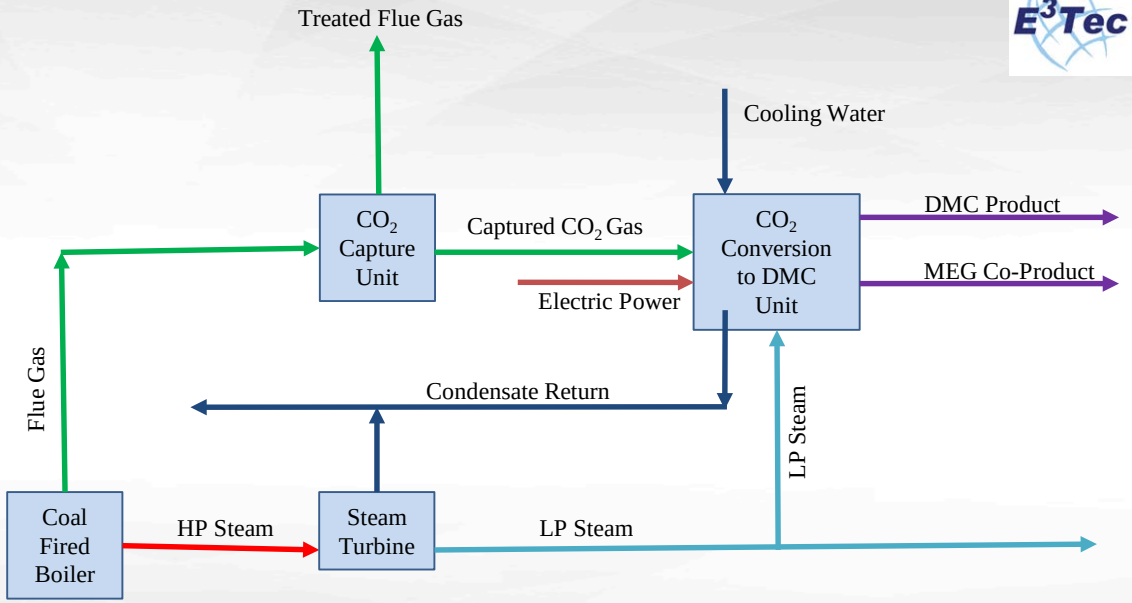
FACE ring. Wind Direction and velocity are measured in the center, then a computer controls the release of gases to simulate future possible conditions.

Fumigation ring is 30 m in diameter. At the center of the ring, wind speed and direction is monitored in real time

http://soyface.illinois.edu/

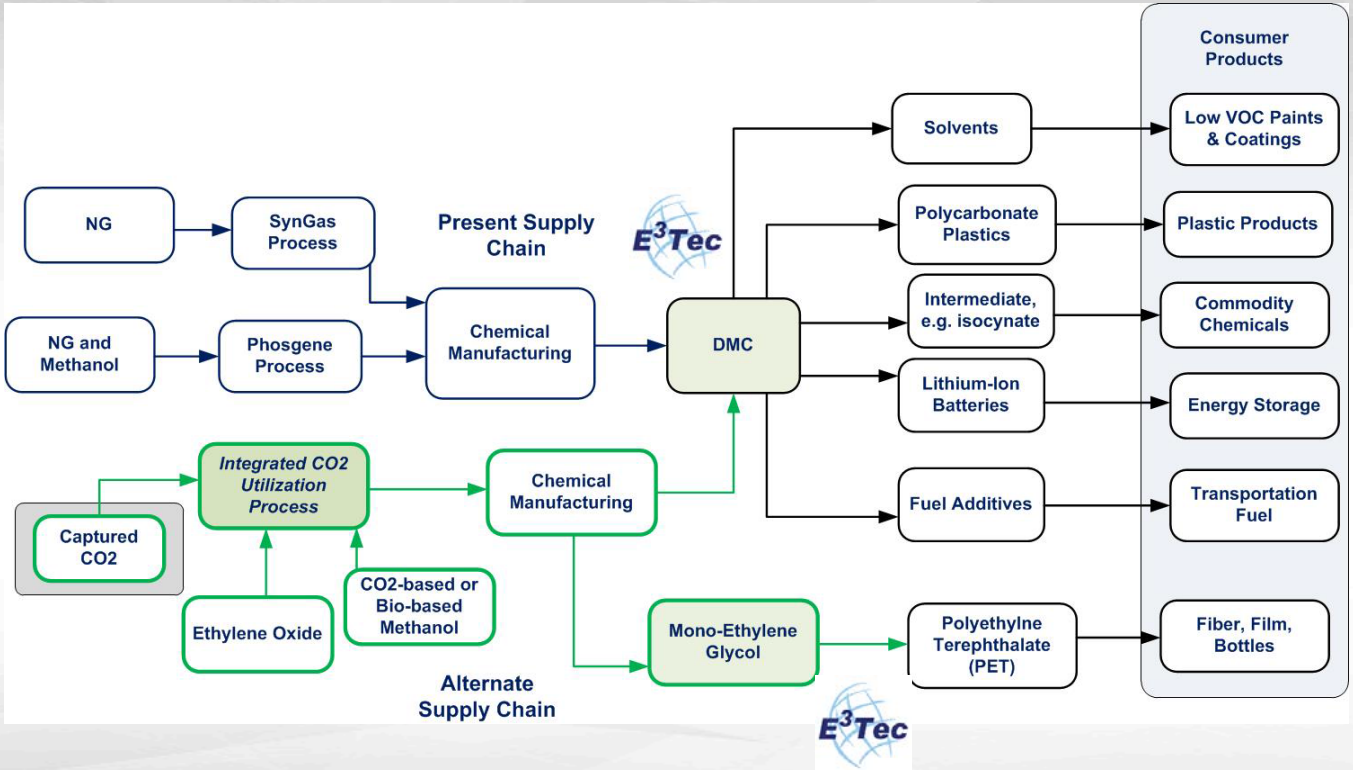
Heat Integrated Reactive Distillation

Manufacturing DMC with co-production of Mono Ethylene Glycol



Supply Chain

Di-Methyl Carbonate (DMC) and Mono-Ethylene Glycol (MEG)



Partners connected into relevant supply chains

WORKFORCE DEVELOPMENT

Training Operators and Engineers

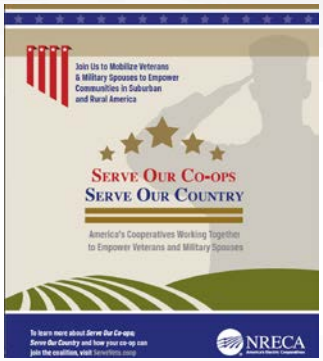
Partners already connected into existing supply chains

ILLINOIS EASTERN COMMUNITY COLLEGES

Southern Illinois University Carbondale

Association of Illinois Electric Cooperatives

Your Touchstone Energy® Partner



EASTERN ILLINOIS UNIVERSITY

COLES-MOULTRIE Electric Cooperative

COLES Together
The economic development organization for Coles County

PRAIRIE RESEARCH INSTITUTE

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Linde

BASF We create chemistry

NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

AEI Affiliated Engineers

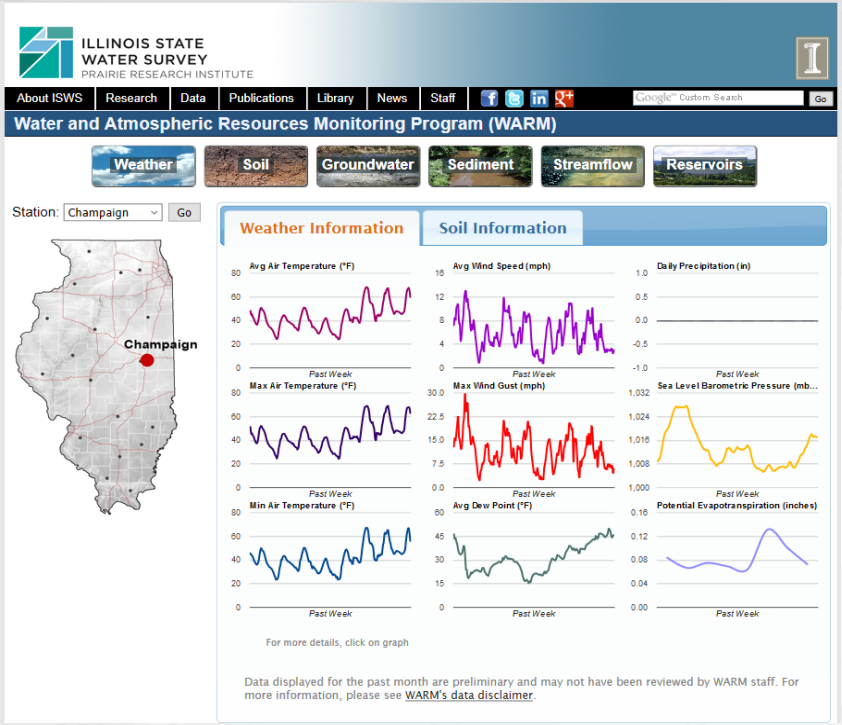
U.S. DEPARTMENT OF ENERGY

Enable connection of utilization with existing infrastructure

APPLYING EXISTING TOOLS

Weather and Atmospheric Monitoring Program (WARM)

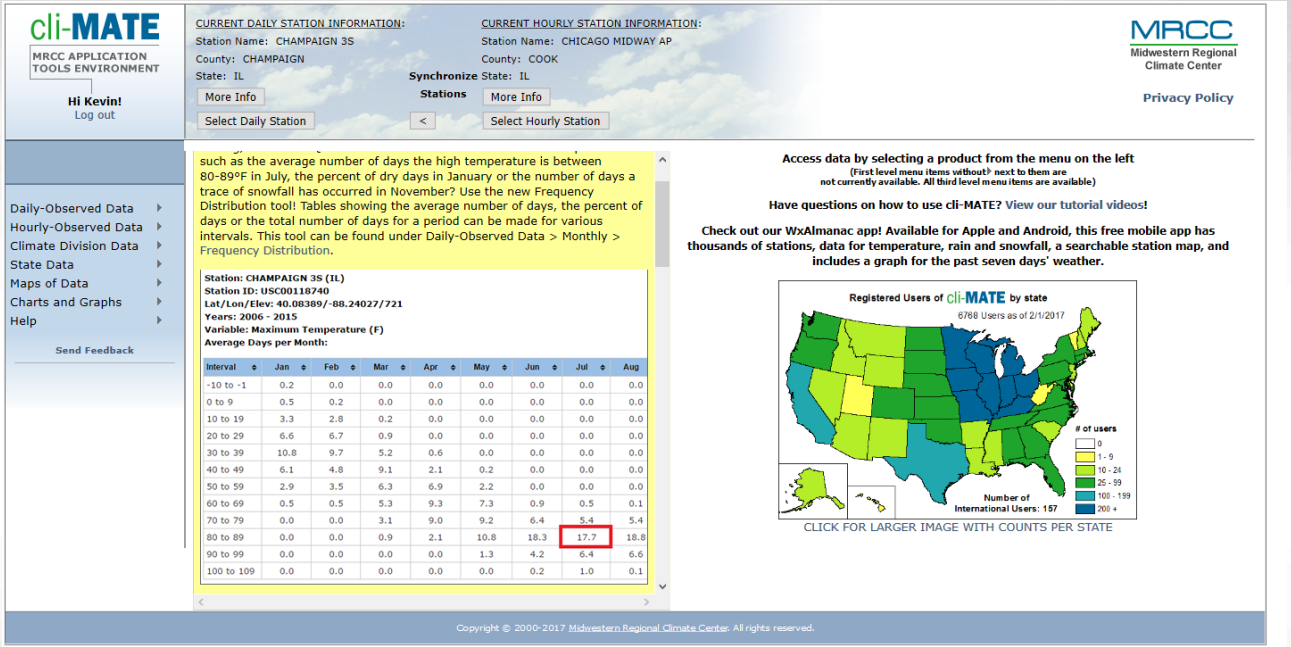
Weather, soil, groundwater, streamflow, and reservoir data relevant for agriculture



- Data collected at 19 stations
- Five (5)minute, hourly, and daily data available
- Daily maps, weekly trends, and historical daily data at http://www.isws.illinois.edu/warm/weather/

Mid-West Regional Climate Center

Tools that can be used to make "CO_2 dispatch" decisions



http://mrcc.isws.illinois.edu/CLIMATE/welcome.jsp

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